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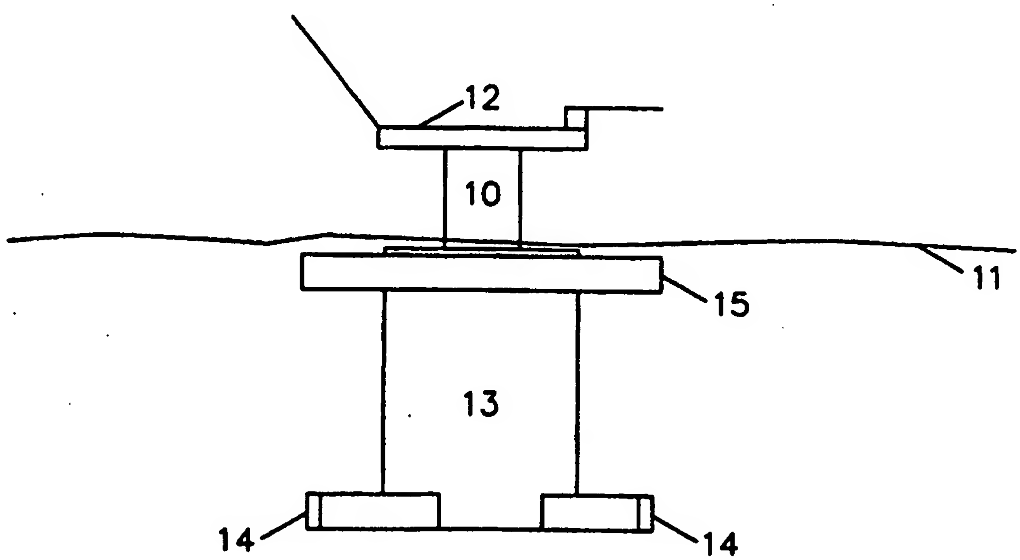
**(54) Title:** TENSION-LEG PLATFORM WITH FLEXIBLE TENDONS AND PROCESS FOR INSTALLATION




**(57) Abstract**

A process comprising: fixing a first end of a tendon to an anchor; lowering the anchor to the sea floor; securing the anchor to the sea floor; fixing a second end of the tendon to the platform. A tendon comprising: a flexible line that extends from the TLP to the anchor, wherein the flexible line comprises a top end and a bottom end; an attacher of the top end of the flexible line to the TLP and an attacher of the bottom end of the flexible line to the anchor. A platform comprising: a platform for floating on the surface of the sea; an anchor for attachment to the sea floor; and a flexible tendon for securing the platform to the anchor.

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TENSION-LEG PLATFORM WITH FLEXIBLE TENDONS AND PROCESS FOR INSTALLATION

This invention relates generally to deep water, mineral production, tension-leg platforms (TLPs) vessels and more specifically to methods and mechanisms for securing the TLP to the sea floor.

Recently, relatively smaller platforms have been developed for deep sea operations where marginal production does not merit the use of a full scale tension-leg platform (TLP). These marginal platforms use tension-leg mooring, like conventional tension-leg platforms, but comprise smaller floatation structures. Tension-leg mooring typically comprises rigid, single-piece tendons for anchoring the structure to the sea floor, like that disclosed in "Monopod TLP Improves Deepwater Economics", *Petroleum Engineer International* (January 1993), incorporated herein by reference. The rigid, single-piece tendons comprise a length of solid metal with buoyancy devices attached at each end. The tendons are towed to the production site and upended by flooding the lower permanent buoyancy tank. The upper permanent buoyancy tank is oversized so the tendons can be left self-standing. Also, the permanently attached buoyancy tanks make premature detachment impossible. The structure of the TLP is then ballasted by a large derrick and lowered to the previously installed tendons and then deballasted to fully tension the tendons.

Single-piece tendon systems, however, are costly to install and remove. Because single-piece tendons are inflexible, they are difficult to handle and must be buoyed and dragged from one location to another as they float on the surface of the sea. This becomes difficult in harsh weather conditions. Further, all of the tendons for a given TLP must be attached to the sea floor and the TLP must be ballasted for attachment to the tendons. TLPs are unsteady, so that it is difficult to make the connection between the free floating TLP and upended tendons. Thus, large derricks are required to stabilize the TLP for connection or

disconnection to the tendons. Also, single-piece tendons only allow the TLP to be anchored at locations where the water is a specific depth because the lengths of the tendons cannot be modified.

Therefore, there is a need for tendons of variable length which may be more economically installed and removed from production sites.

An object of the present invention is to address the above problems by a system which uses flexible tendons which are individually attached to independent anchors. Each tendon with its corresponding anchor is lowered to the sea floor, where the anchor is fixed. The tendons may be secured at variable positions so that the TLP may be anchored to the sea floor in locations of varying depth.

According to one aspect of the invention, there is provided a process comprising: fixing a first end of a tendon to an anchor; lowering the anchor to the sea floor; securing the anchor to the sea floor; fixing a second end of the tendon to the platform.

According to another aspect of the invention, there is provided a tendon comprising: a flexible line that extends from the TLP to the anchor, wherein the flexible line comprises a top end and a bottom end; an attacher of the top end of the flexible line to the TLP; and an attacher of the bottom end of the flexible line to the anchor.

According to a further aspect of the invention, there is provided a platform comprising: a platform for floating on the surface of the sea; an anchor for attachment to the sea floor; and a flexible tendon for securing the platform to the anchor.

The present invention is better understood by reading the following description of nonlimitative embodiments with reference to the attached drawings, wherein like parts in each of the several figures are identified by the same reference character, which are briefly described as follows:

FIG. 1 is a plan view of one embodiment of the inventive tension-leg platform.

FIG. 1a is a plan view of a prior art monopod TLP.

FIG. 1b is a top view of an embodiment of a generator of a stabilizing moment.

FIG. 1c is a top view of an embodiment of a generator of a stabilizing moment.

FIG. 2 is a flow chart describing the steps for assembling the tension-leg platform.

FIG. 3a is a plan view of the main buoyancy structure and float as constructed on land.

FIG. 3b is a plan view of the main buoyancy structure and float launched into the water.

FIG. 3c is a plan view of the main buoyancy structure and float ballasted in horizontal orientations.

FIG. 3d is a plan view of the main buoyancy structure and float locked together.

FIG. 3e is a plan view of the main buoyancy structure and float ballasted to a vertical orientation.

FIG. 3f is a plan view of the tension-leg platform and barge for assembling the platform.

FIG. 3g is a top view of the tension-leg platform and barge for assembling the platform.

FIG. 4 is a flow chart describing the steps for attaching the tension-leg platform to the sea floor.

FIG. 5a is a plan view of the attachment apparatuses for attaching a tendon of the tension-leg platform to the sea floor in an initial mode of operation.

FIG. 5b is a plan view of the attachment apparatuses for attaching the tendon to the sea floor in a subsequent mode of operation.

FIG. 5c is a plan view of the attachment apparatuses for attaching the tendon to the sea floor after the tendon is secured.

FIG. 6 is a plan view of the attachment apparatuses for attaching a second tendon to the sea floor.

FIG. 7 is a plan view of the tendon and suction anchor.

FIG. 8a is a plan view of the ROV-POD and anchor.

FIG. 8b is a plan view of the ROV-POD, anchor, and attachment dowel.

FIG. 9a is a plan view of the apparatus for attaching the tendon to the tension-leg platform.

FIG. 9b is a side view of a sliding deflector.

FIG. 9c is a side view of a sliding deflector.

FIG. 10a is a plan view of the tension-leg platform in a presecured configuration.

FIG. 10b is a plan view of the tension-leg platform in a postsecured configuration.

FIG. 11a is a plan view of an embodiment of an attacher of the generator to the TLP.

FIG. 11b is a plan view of an embodiment of an attacher of the generator to the TLP and a top view of the generator alone.

FIG. 11c is a plan view of an embodiment of an attacher of the generator to the TLP.

It is to be noted, however, that the appended drawings illustrate only typical embodiments of the invention and are therefore not to be considered a limitation of the scope of the invention which includes other equally effective embodiments.

Referring to Fig. 1, one embodiment of a tension-leg platform according to the present invention is shown. The tension-leg platform (TLP) comprises a monopod configuration. The portion of the TLP 9 which extends above the water surface 11 comprises the monopod 10 and the platform 12. The portion of the TLP 9 that extends below the water surface 11 comprises a main buoyancy structure 13, pontoons 14, and a float 15. The main buoyancy structure 13 is cylindrical in shape with its longitudinal axis oriented in a vertical position when the tension-leg platform 9 is arranged in an operational configuration. The pontoons 14 are attached to the bottom of the main buoyancy structure 13 and extend horizontally outward from the central axis of the main buoyancy structure 13. The float 15 is configured so that it encircles the main buoyancy structure 13. Further, float 15 may be moved from a position near the top of the main buoyancy structure 13 to a position at the bottom of main buoyancy structure 13 near pontoons 14. The float 15

comprises a generator of a stabilizing moment because it serves to return the vertical central axis of the TLP to a vertical position upon deflection by wave, wind, etc. which act on the TLP.

As shown in Fig. 1b, the generator of a stabilizing moment may also comprise a structure with at least three extensions 51 which extend radially out from the central axis of the TLP. Displacers of seawater 52 are attached at the ends of the extensions 51. Also, as shown in Fig. 1c, the displacers of seawater 52 may be merged to a single structure. This structure may assume any geometric shape so long as it displaces uniform volumes of seawater symmetrically.

Referring to Figs. 2 and 3a - 3g, a flow chart is shown for the construction of a tension-leg platform and drawings depicting each step of the process, respectively. First, the main buoyancy structure 13 is constructed 201 with the monopod 10 attached. Also, portions of the pontoons 14 are also attached to the main buoyancy structure 13. Further, the float 15 is constructed 201 separately. The main buoyancy structure 13 and float 15 are then launched 202 into the water. At this point, the float 15 lays flat upon the surface of the water while main buoyancy structure 13 is oriented horizontally. The remaining sections of pontoons 14 are attached 202 to the sections which had originally been attached to main buoyancy structure 13. The pontoons are attached in two sections at a time because of the difficulty in transporting main buoyancy structure 13 across a surface when pontoons 14 are too lengthy. Thus, main buoyancy structure 13 is rolled in the water to expose each pontoon in sequence so that an additional section may be added to each. Next, the float 15 is ballasted 203 so that its central axis is oriented in a horizontal direction. With the pieces of the tension-leg platform in the horizontal orientation, the pieces can be easily assembled. Float 15 is slipped 204 over the monopod 10 and onto the main buoyancy structure 13. It is then attached to the main buoyancy structure 13 at the end closest to the monopod 10.

Next, the tension-leg platform is ballasted 205 so that it is oriented with the longitudinal axis of the main buoyancy structure 13 in a vertical direction. The float 15 also has its central axis in a vertical direction and resides just below the surface of the water 11. Thus, the main buoyancy structure 13 and the pontoons 14 extend below the surface of the water while the monopod 10 extends above the surface of water 11. Note that in this orientation, the tension-leg platform may be transported 206 to the site for operation, although it may also be towed disassembled and assembled on site. Upon reaching the site, the tension-leg platform is ballasted 207 so that the entire tension-leg platform sinks deeper into the water so as to expose only a portion of the monopod 10. A barge 16 is used to transport a platform 12 to the operation site. The barge 16 has a notch 17 which is large enough to encircle the monopod 10. Thus, with the tension-leg platform in a lowered position, the barge 16 may position the platform 12 above the monopod 10. The platform 12 is then assembled 208 to the monopod 10. Finally, the assembled TLP is deballasted 209. The tension-leg platform is now fully assembled and may now be attached to the ocean floor for operation.

Referring to Figs. 4, 5a, 5b, 5c, and 6, steps for the process of attaching the tension-leg platform to the sea floor and drawings disclosing the process are shown. First, a tension-leg platform 9 and a support vessel 18 are both position 401 over the mooring site. A tendon 19 and a remotely operated vehicle (ROV) are attached 402 to and anchor 20. The anchor 20 is lowered from the support vessel 18 by the tendon 19. As the suction anchor and ROV are lowered towards the sea floor 23, the tendon 19 is unspooled from the support vessel 18. An umbilical cord 24 for the ROV and suction anchor is attached to the ROV and is also unspooled as the suction anchor is lowered. After the anchor 20 is placed on the sea floor 23, an auxiliary wire 70 is extended 403 from the TLP 9 to retrieve the free end of the tendon 19 as it is released from the support vessel 18. Alternatively, the free end of the tendon 19 may be

transferred before the anchor 20 reaches the sea floor 23 by the auxiliary wire 70 and a hook wire 22. The weight of the anchor and tendon would then be supported by the auxiliary wire 70 and hook wire 22 during the transfer.

The weight of the tendon 19 and suction anchor 20 is then assumed 404 by the TLP and the ROV is used 404 to place the anchor 20 in the desired location. This is doe because the tension-leg platform 19 is much more stable than the support vessel 18 so as to provide more stability when placing the suction anchor 20 upon the sea floor 23. The ROV 21 is operated 404 to place the suction anchor 20 in the desired location while the tendon 19 lowers the suction anchor 20 to the sea floor 23. The suction anchor 20 is then attached 405 to the sea floor 23 and the ROV is removed 405. This procedure is more fully described below. A winch or other pulling device is then used to pull 406 on the free end of the tendon 19 until the desired tension is obtained. Finally, the tendon 19 is secured 406 to the TLP. This attachment step 406 is more fully described below.

Upon deposit of the suction anchor 20 on the sea floor, the ROV 20 and auxiliary wire 22 are returned 405 to the support vessel 18 where they are again attached 407 to a second suction anchor 25. A second tendon 27 is also attached 407 to the anchor 25. Additionally, a tether 26 is attached 408 from the anchor 25 to the tendon 19 which is already secured to the sea floor 23. Again, the tendon 27 is used to lower 409 the anchor 25 to the sea floor 23. The free end of the tendon 27 is transferred to the TLP and the ROV 21 is used to pull the anchor 25 horizontally away from anchor 20 so that tether 26 is fully extended. Tendon 27 then lowers anchor 25 to the sea floor 23 where it is attached. The process is then repeated for subsequent anchors until all anchors are placed on the sea floor 23 in their proper positions.

Referring to Fig. 7, one embodiment of the suction anchor is shown. First of all, the tendon 19 is attached to one end of a chain 28. A spinner 63 is used to make the connection so that the tendon 19 may rotate relative to the

chain 28. The other end of the chain 28 is inserted into a funnel 29 located near the top of the anchor 20. Inside the funnel 29, the chain 28 is engaged by a chain stopper 30 which locks it into place. Excess links of the chain 28 are stored in a chain locker 31 below the funnel 29.

In one embodiment, for a TLP weighing about 6,000 tons, the chain 28 may comprise four inch, oil-rig-quality chain. The tendon may comprise spiral strand wire having a 110 mm diameter. Further, the suction anchor 20 may be made of single steel cylinder with a wall thickness of 20 mm. The total weight of the anchor may range from about 25 toes (3.5 m diameter and 7.5 m long) to about 40 tons (5 m diameter and 11 m long). See J-L. Colliat, P. Boisard, K. Andersen, and K. Schroeder, "Caisson Foundations as Alternative Anchors for Permanent Mooring of a Process Barge Offshore Congo", *Offshore Technology Conference Proceeding*, Vol. 2, pgs. 919-929 (May 1995); E. C. Clukey, M. J. Morrison, J. Garnier, and J. F. Corté, "The Response of Suction Caissons in Normally Consolidated Clays to Cyclic TLP Loading Conditions", *Offshore Technology Conference Proceeding,* Vol. 2, pgs. 909-918 (May 1995), both incorporated herein by reference.

The ROV 21 is attached to a ROV pod 32. The ROV pod 32 in turn engages the anchor 20. As shown in Fig. 8a, the ROV pod 32 comprises a series of rings 33. The anchor 20 also has a series of rings 34. The devices are connected by bringing the ROV pod 32 in close proximity with the anchor 20 so that rings 33 are placed adjacent to rings 34. As shown in Fig. 8b, with the rings juxtaposed, a dowel 35 may be inserted into the rings 33 and 34 to connect the ROV pod 32 to the anchor 20.

Referring again to Fig. 7, the anchor 20 also comprises a series of chambers 36. Each of these chambers are closed on all sides with the exception of the bottom side which is adjacent to the sea floor 23. The anchor is attached to the sea floor 23 by pumping air into the chambers 36 with air supplied by umbilicals 24. Water is pushed out from the chambers by the air through one-way valves between the

chambers and the exterior of the anchor. Once the chambers are filled with air, the air is immediately evacuated to create low pressure inside the chambers. This creates a suction which causes the anchor to adhere to the sea floor 23. The air may be evacuated by pumps or by allowing the air in the anchor to be exposed to atmospheric pressure at the sea surface via a hose. When the anchor is to be released from the sea floor, air is pumped back into the chambers to increase the pressure. Multiple chambers 36 provide redundancy to prevent the entire anchor from becoming detached should one of the chambers fail.

Referring to Fig. 9a, an embodiment is shown for attachment of the tendon 19 to the tension-leg platform 9. The tendon 19 is attached to a chain 37 with a spinner 63 in between. The spinner 63 allows the tendon 19 to rotate relative to the chain 37. The chain 37 enters the tension-leg platform 9 through one of the pontoons 14. The chain 37 is then directed through the pontoon 14 and up through the main buoyancy structure 13 of the tension-leg platform 9. A deflector 38 is located at the point where the chain enters pontoon 14 so as to deflect the direction of the chain. The chain enters the pontoon in a vertical direction and is deflected by a fairlead or deflector 38 toward the central axis of the buoyancy structure 13. Toward the interior of the main buoyancy structure 13, the chain is again deflected by a second fairlead or deflector 39 which directs the chain vertically toward the monopod 10.

These deflectors may comprise pulleys, sliding material, or any other device known. Fig. 9b shows a side view of sliding deflector embodiment. The chain 37 slides within a groove 71 in the deflector 38 which conforms to the shape of the chain. Alternatively, as shown in Fig. 9c, a cable 73 may be deflected by the deflector 38 in which case the groove 71 conforms to the shape of the cable 73. Monoloy material, produced by Smith-Berger of Vancouver, Washington, is a suitable sliding material.

Referring again to Fig. 9a, a wire 41 is attached to the free end of the chain 37. The wire 41 is engaged by a

handling winch 42 which pulls the free end of the chain 37 vertically so that the chain 37 and the tendon 19 become tight. When a desired tension is obtained, the chain 37 is locked into place by a stopper 40 which is located in the monopod 10. A stopper 40 may comprise two protrusions which straddle a link of the chain so as to catch the next subsequent link in the chain. However, automatic stopping system, known in the art, may also be used. This stopper 40 may comprise a series of stoppers which engage the chain 37 at various positions. Multiple stoppers are used to provide redundancy should one of the stoppers fail. It should be understood that the stoppers may be located anywhere inside the tension-leg platform 9, however, placement inside the monopod makes them easily accessible. Further, a similar chain configuration is used for each of the tendons 19 which are used to secure the tension-leg platform 9 to the sea floor 23. The winch 42 and wire 41 are used to induce tension in each of the tendons, 19, 27, etc., sequentially.

Referring to Figs. 10a and 10b, embodiments of the present invention are shown. In Fig. 10a, configuration of the float 15 is such that it is affixed towards the upper end of main buoyancy structure 13. In this configuration, the float 15 provides stability to the tension-leg platform 9 because of the increased water displacement at the surface of the water. Thus, in this configuration, the tension-leg platform 9 has increased stability which is important during the attachment of the tendons 27 to the sea floor 23 and to the tension-leg platform 9.

However, as soon as the tendons 27 are securely in place, the water displacement at the surface is no longer needed. In fact, once the tension-leg platform 9 is secured to the sea floor, increased surface area of the tension-leg platform 9 at the surface of the water 11 is detrimental. As the waves act on the large surface area of the float 15 (see Fig. 1a), they induce resonance in the tension-leg platform 9 until the amplitude of the resonance is such that the tendons 27 begin to break. Therefore, as shown in Fig. 10b, once the tendon-leg platform 9 has secured to the sea

floor, the float 15 is moved by a mover so that it is lowered until it abuts against the pontoons 14. The mover of the float 15 may comprise ballast, a pulley cable system, a hydraulic system, or any other system known. The float 15 is then attached to the pontoons 14 and to the main buoyancy structure 13 and the ballast is removed. Thus, the float 15 provides buoyancy to the tension-leg platform 9 below the wave zone of the sea. In this configuration, the tension-leg platform 9 has a smaller cross-section upon which the waves at the surface act. Additionally, with the float secured to the tension-leg platform 9, the added buoyancy allows the tension-leg platform to support several risers (not shown) which will be brought from the sea floor.

In this regard, the float 15 comprises a reducer of the size of the TLP in the wave zone because once the float 15 is submerged to where it no longer pierces the surface of the sea, it does not displace seawater in the wave zone. The reducer of the size of the TLP in the wave zone may also comprise a device which removes or reconfigures TLP structural elements so that less water is displaced in the wave zone. For example, a crane may be used to remove members which support the TLP during transportation and assembly, but which are not required when the TLP is secured to the sea floor.

Referring to Fig. 11a, an attacher of the float to the TLP is shown. The generator of a stabilizing moment (float 15) comprises a generator thread 55 which allows float 15 to be twisted first onto the TLP thread 56 and second onto TLP thread 57. As shown in Fig. 11b, the attacher may comprise dowels 58 which extend between the TLP and the generator of a stabilizing moment (float 15) through dowel holes 59. In Fig. 11c, the attacher is shown to comprise generator teeth 60 and TLP teeth 61. The TLP teeth 61 are tracks of teeth which extend parallel to the TLP central axis on the outside of the main buoyancy structure 13. The generator teeth 60 are gears mounted on the generator of a stabilizing moment 15 for engagement with the TLP teeth 61.

It is to be noted that the above described embodiments illustrate only typical embodiments of the invention and are therefore not to be considered a limitation of the scope of the invention which includes other equally effective embodiments.

## C l a i m s

1. A process for affixing a deep sea, mineral production, tension-let platform (TLP) to the sea floor, the process comprising:

fixing a first end of a tendon to an anchor;
lowering the anchor to the sea floor;
securing the anchor to the sea floor; and
fixing a second end of the tendon to the platform.

2. A process as in claim 1, wherein said fixing a first end of a tendon comprises:

attaching the first end to a first chain; and
attaching the first chain to the anchor.

3. A process as in claim 1, wherein said lowering comprises:

suspending the anchor from a wire;
extending the wire toward the sea floor; and
releasing the wire from the anchor.

4. A process as in claim 1, wherein said lowering comprises extending the tendon toward the sea floor.

5. A process as in claim 1, wherein said securing comprises driving the anchor into the sea floor.

6. A process as in claim 1, wherein said securing comprises reducing pressure between the anchor and the sea floor so that the anchor adheres to the sea floor.

7. A process as in claim 1, wherein said fixing a second end of the tendon comprises:

attaching the second end of the tendon to a second chain; and
attaching the second chain to said TLP.

8. A tendon for securing a deep sea, tension-leg platform (TLP) to an anchor affixed to the sea floor, the tendon comprising:

a flexible line that extends from the TLP to the anchor, wherein said flexible line comprises a top end and a bottom end;

an attacher of the top end of said flexible line to the TLP; and an attacher of the bottom end of said flexible line to the anchor.

9. A mechanism as in claim 8, wherein said flexible line comprises a variable length line.

10. A tendon as in claim 8, further comprising a top spinner which is connected between the TLP and the top end of said flexible line, wherein said top spinner allows said flexible line to rotate relative to the TLP.

11. A tendon as in claim 8, further comprising a bottom spinner which is connected between the TLP and the bottom end of said flexible line, wherein said bottom spinner allows said flexible line to rotate relative to the anchor.

12. A tension-leg platform (TLP) for deep water mineral production, the platform comprising:

a platform for floating on the surface of the sea;
an anchor for attachment to the sea floor; and
a flexible tendon for securing the platform to the anchor.

13. A platform as in claim 12, wherein said platform comprises:

a production platform;
a buoyancy structure;
a monopod which connects said production platform to said buoyancy structure; and
a float for stabilizing said platform which attaches to said buoyancy structure.

14. A platform as in claim 12, wherein said anchor comprises a suction anchor.

15. A platform as in claim 12, wherein said anchor comprises a piling anchor for penetrating the sea floor.

16. A platform as in claim 12, wherein said tendon comprises a variable length tendon.

17. A platform as in claim 12, wherein said tendon comprises a spiral stand wire.

18. A platform as in claim 12, wherein a first end of said tendon is attached to a first chain and a second end of said tendon is attached to a second chain.

19. A platform as in claim 12, wherein said first chain is attached to said anchor and said second chain is attached to said platform.

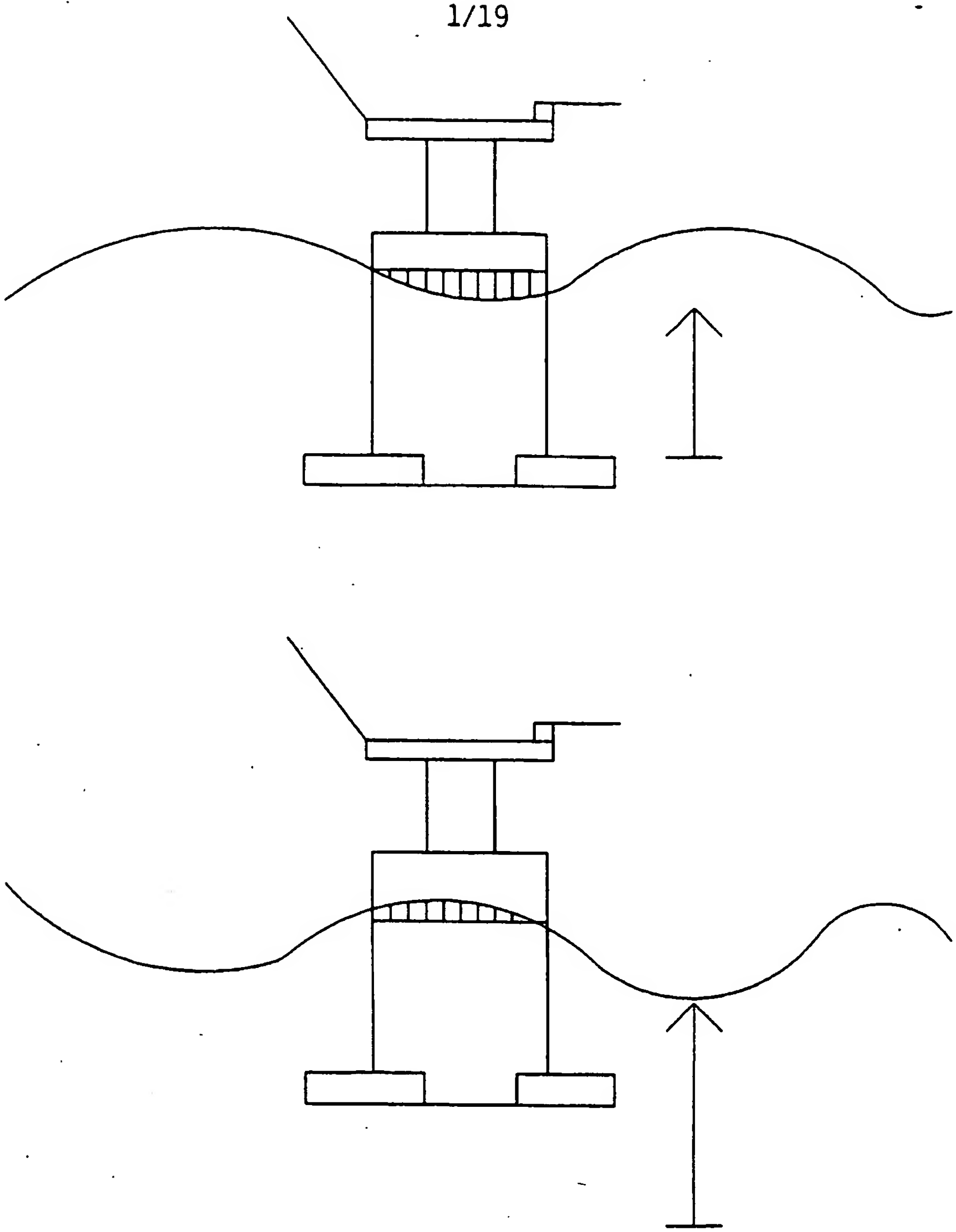

FIG. 1a

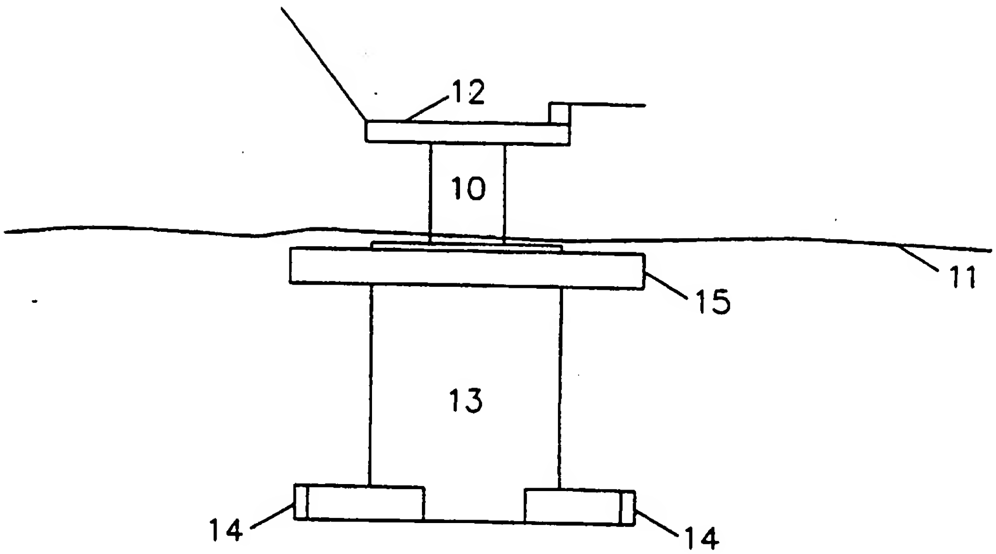


FIG. 1

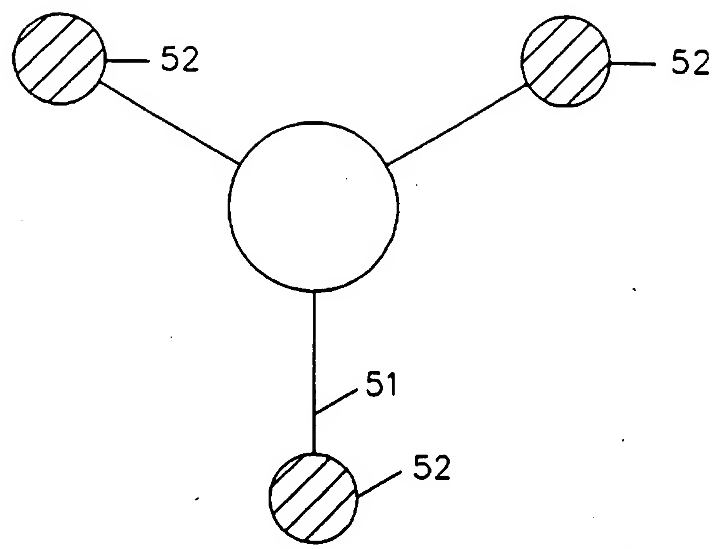


FIG. 1b

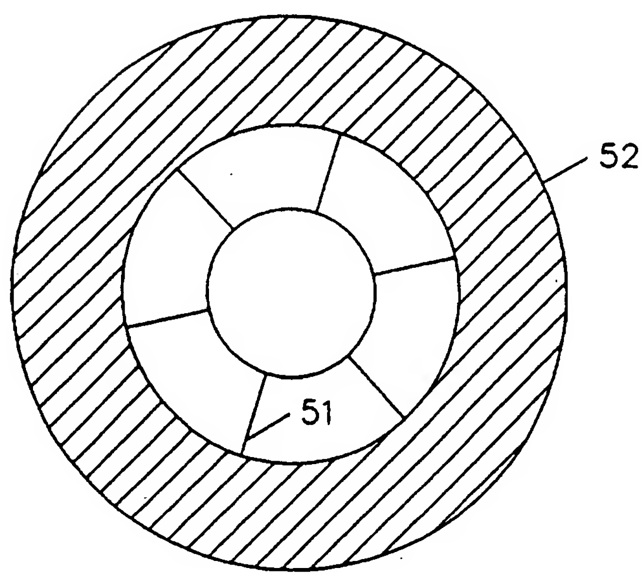


FIG. 1c

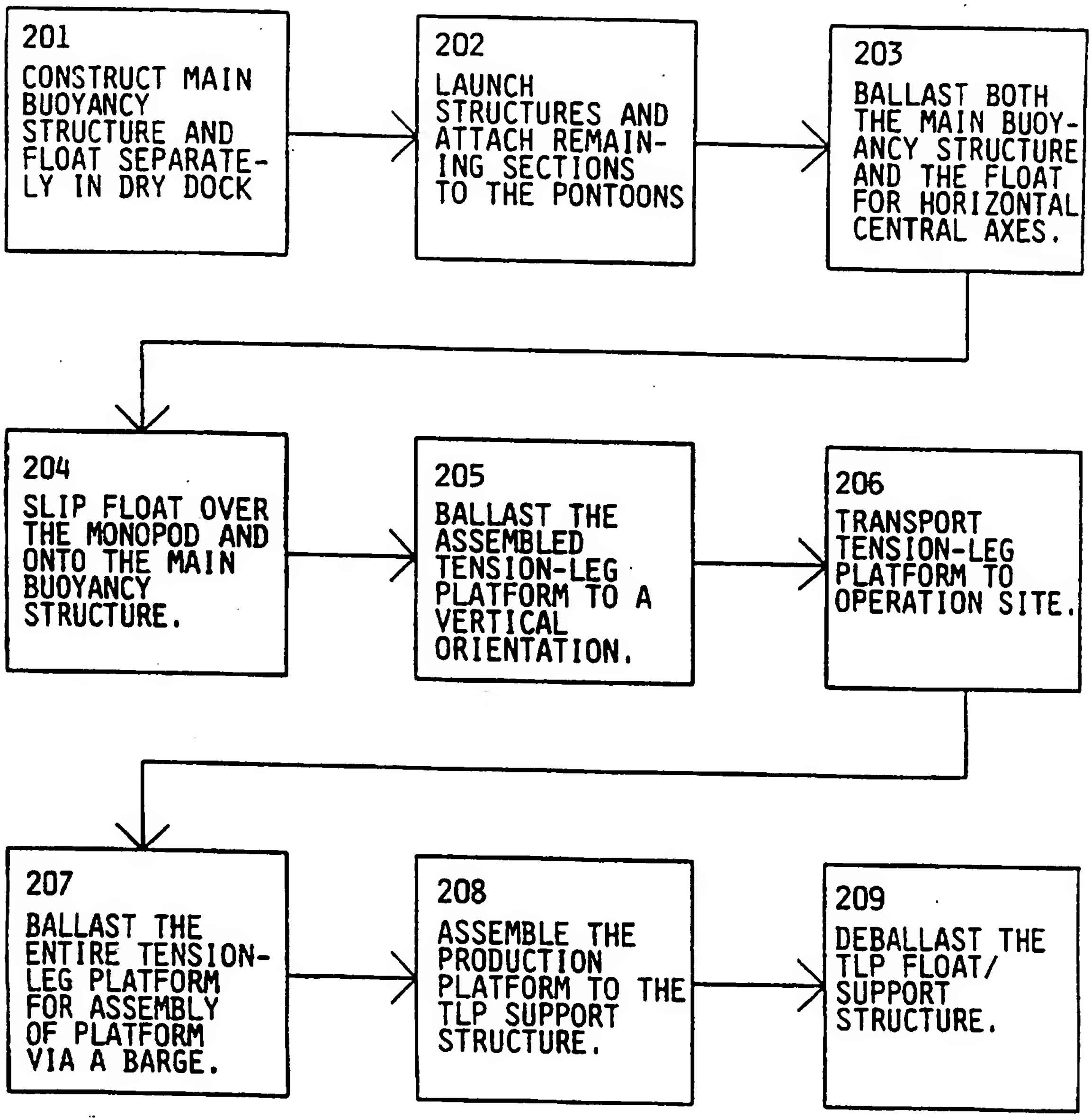
201
CONSTRUCT MAIN BUOYANCY STRUCTURE AND FLOAT SEPARATELY IN DRY DOCK
202
LAUNCH STRUCTURES AND ATTACH REMAINING SECTIONS TO THE PONTOONS
203
BALLAST BOTH THE MAIN BUOYANCY STRUCTURE AND THE FLOAT FOR HORIZONTAL CENTRAL AXES.
204
SLIP FLOAT OVER THE MONOPOD AND ONTO THE MAIN BUOYANCY STRUCTURE.
205
BALLAST THE ASSEMBLED TENSION-LEG PLATFORM TO A VERTICAL ORIENTATION.
206
TRANSPORT TENSION-LEG PLATFORM TO OPERATION SITE.
207
BALLAST THE ENTIRE TENSION-LEG PLATFORM FOR ASSEMBLY OF PLATFORM VIA A BARGE.
208
ASSEMBLE THE PRODUCTION PLATFORM TO THE TLP SUPPORT STRUCTURE.
209
DEBALLAST THE TLP FLOAT/ SUPPORT STRUCTURE.

FIG. 2

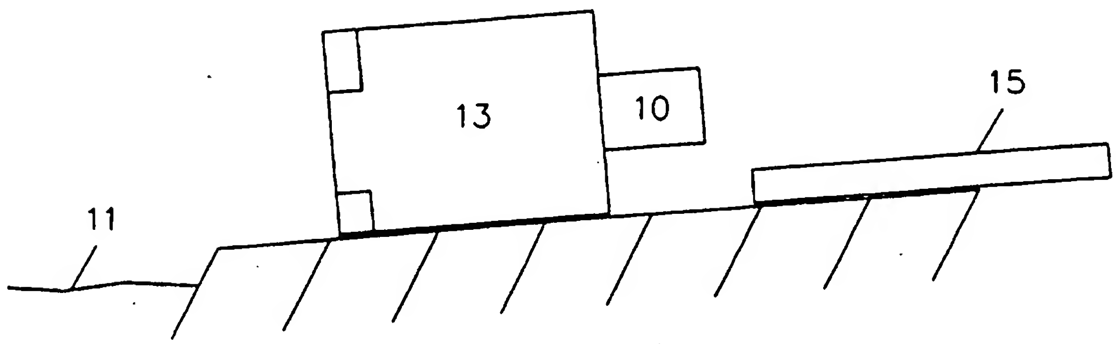


FIG. 3a

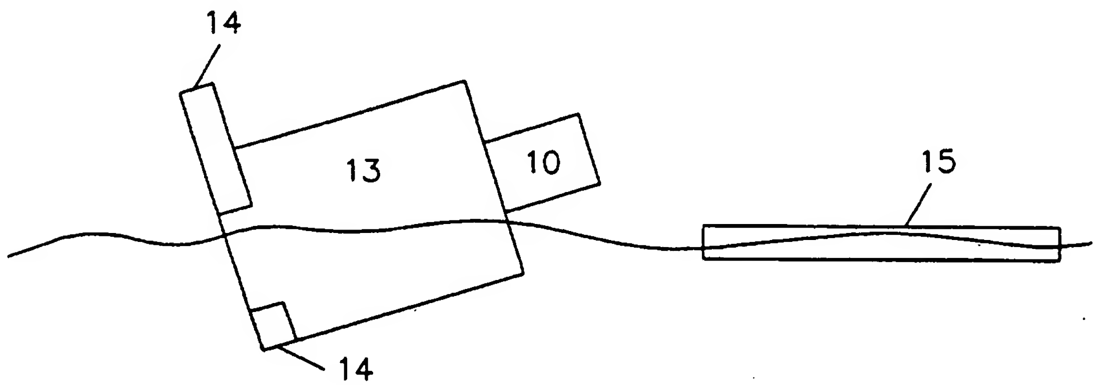


FIG. 3b

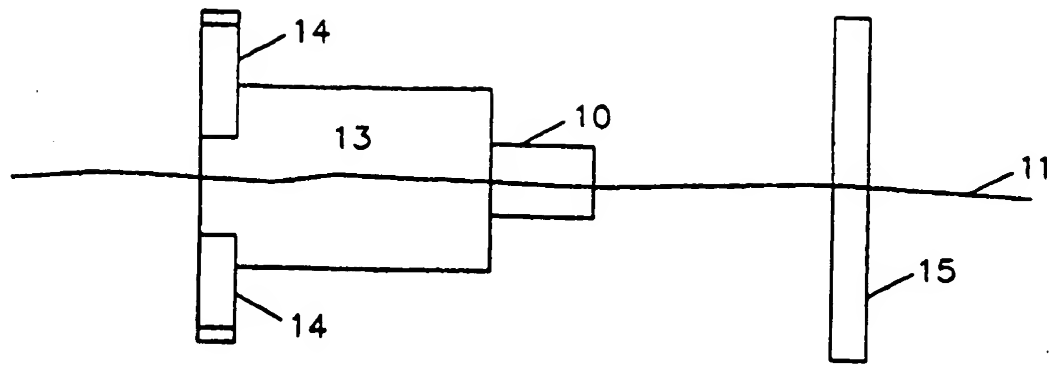


FIG. 3c

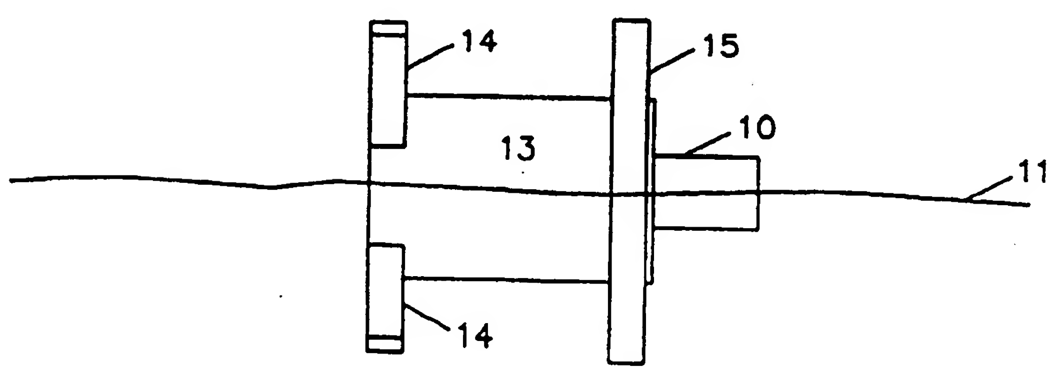


FIG. 3d

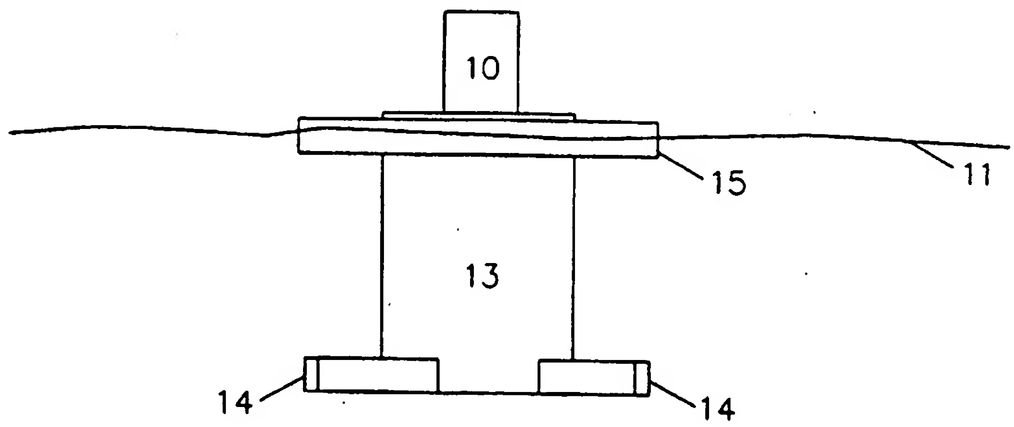


FIG. 3e

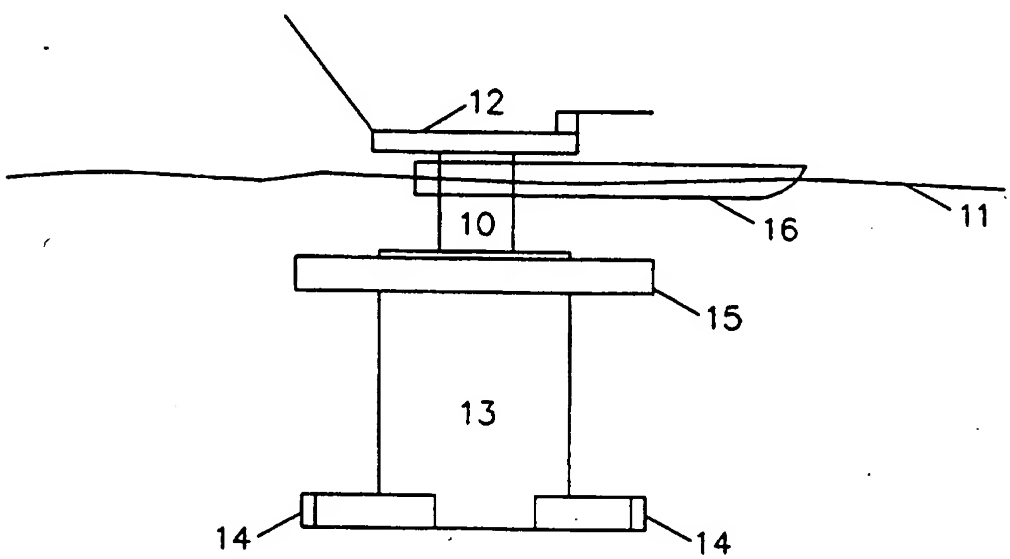


FIG. 3f

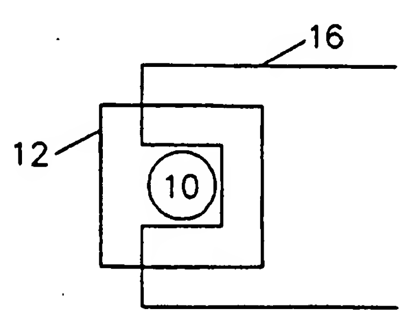


FIG. 3g

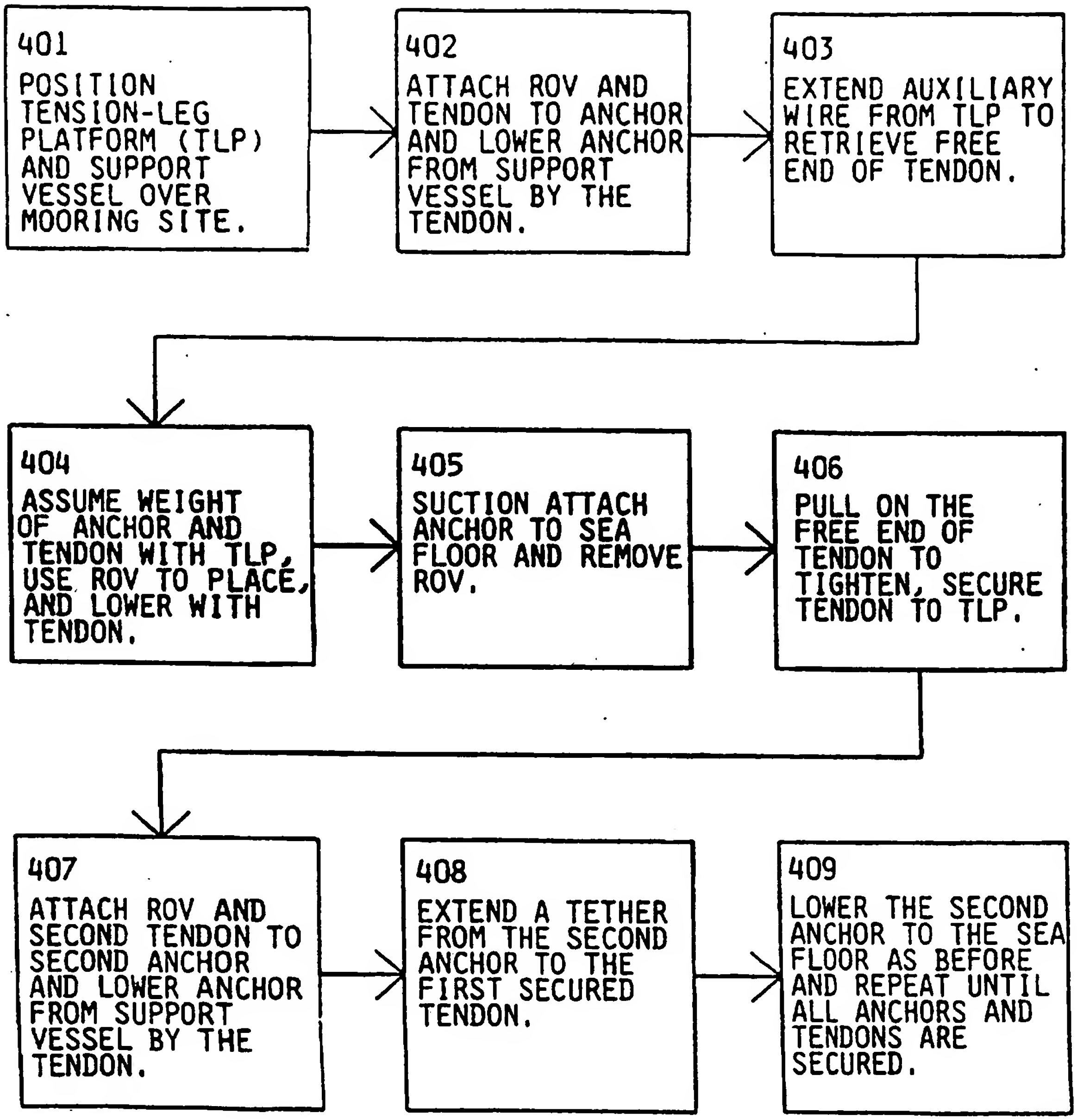
401
POSITION TENSION-LEG PLATFORM (TLP) AND SUPPORT VESSEL OVER MOORING SITE.
402
ATTACH ROV AND TENDON TO ANCHOR AND LOWER ANCHOR FROM SUPPORT VESSEL BY THE TENDON.
403
EXTEND AUXILIARY WIRE FROM TLP TO RETRIEVE FREE END OF TENDON.
404
ASSUME WEIGHT OF ANCHOR AND TENDON WITH TLP, USE ROV TO PLACE, AND LOWER WITH TENDON.
405
SUCTION ATTACH ANCHOR TO SEA FLOOR AND REMOVE ROV.
406
PULL ON THE FREE END OF TENDON TO TIGHTEN, SECURE TENDON TO TLP.
407
ATTACH ROV AND SECOND TENDON TO SECOND ANCHOR AND LOWER ANCHOR FROM SUPPORT VESSEL BY THE TENDON.
408
EXTEND A TETHER FROM THE SECOND ANCHOR TO THE FIRST SECURED TENDON.
409
LOWER THE SECOND ANCHOR TO THE SEA FLOOR AS BEFORE AND REPEAT UNTIL ALL ANCHORS AND TENDONS ARE SECURED.

FIG. 4

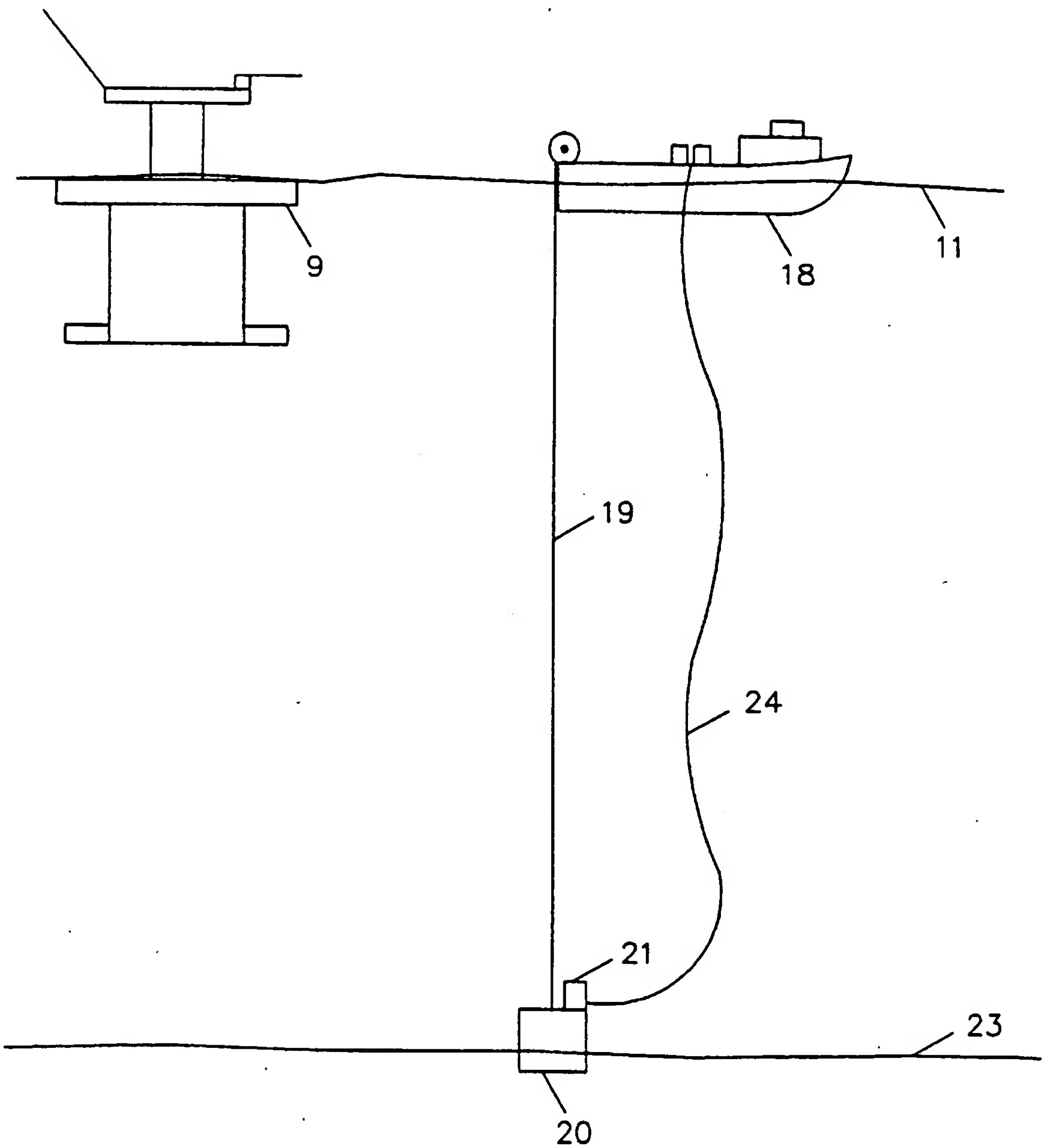


FIG. 5a

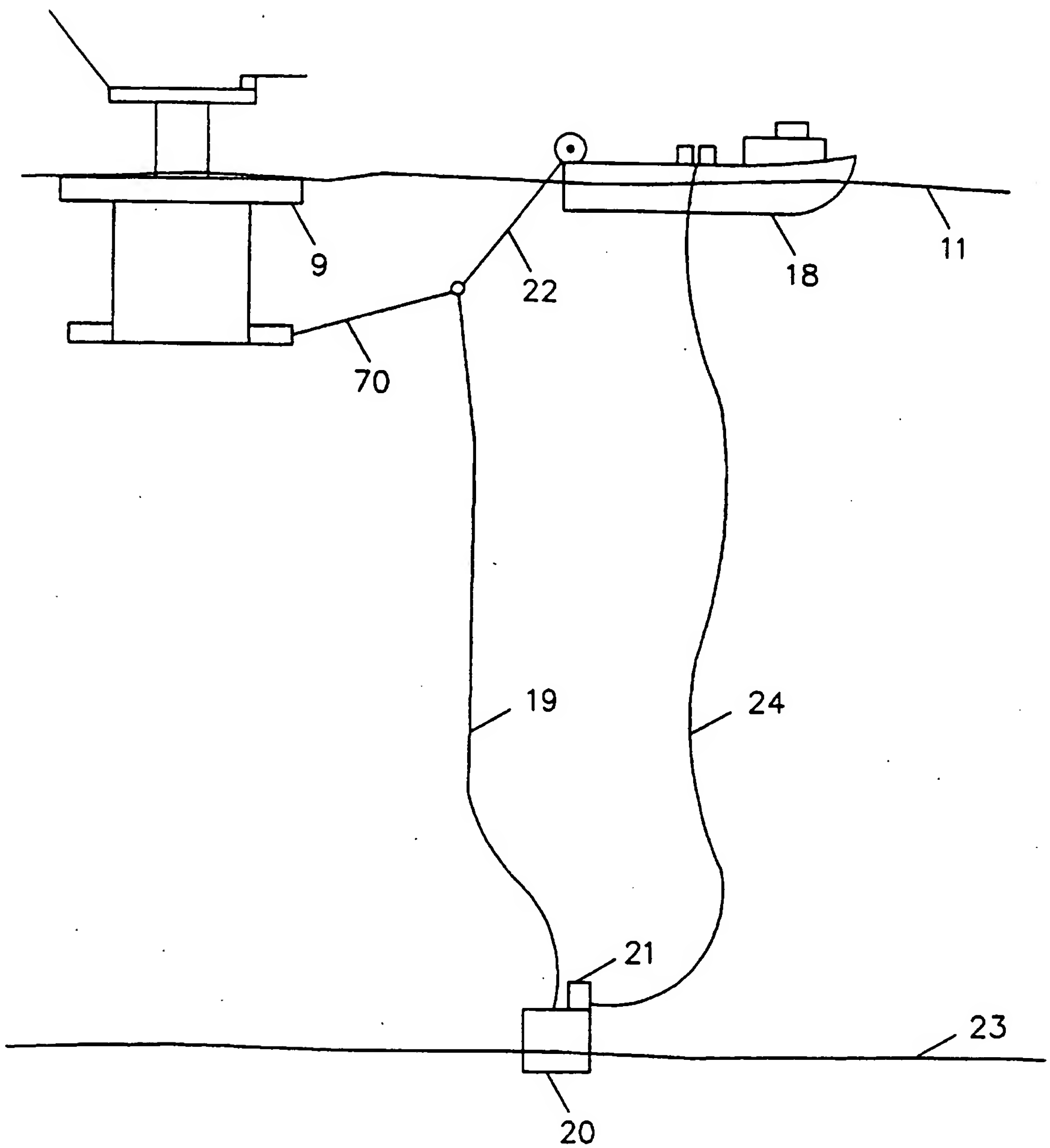


FIG. 5b

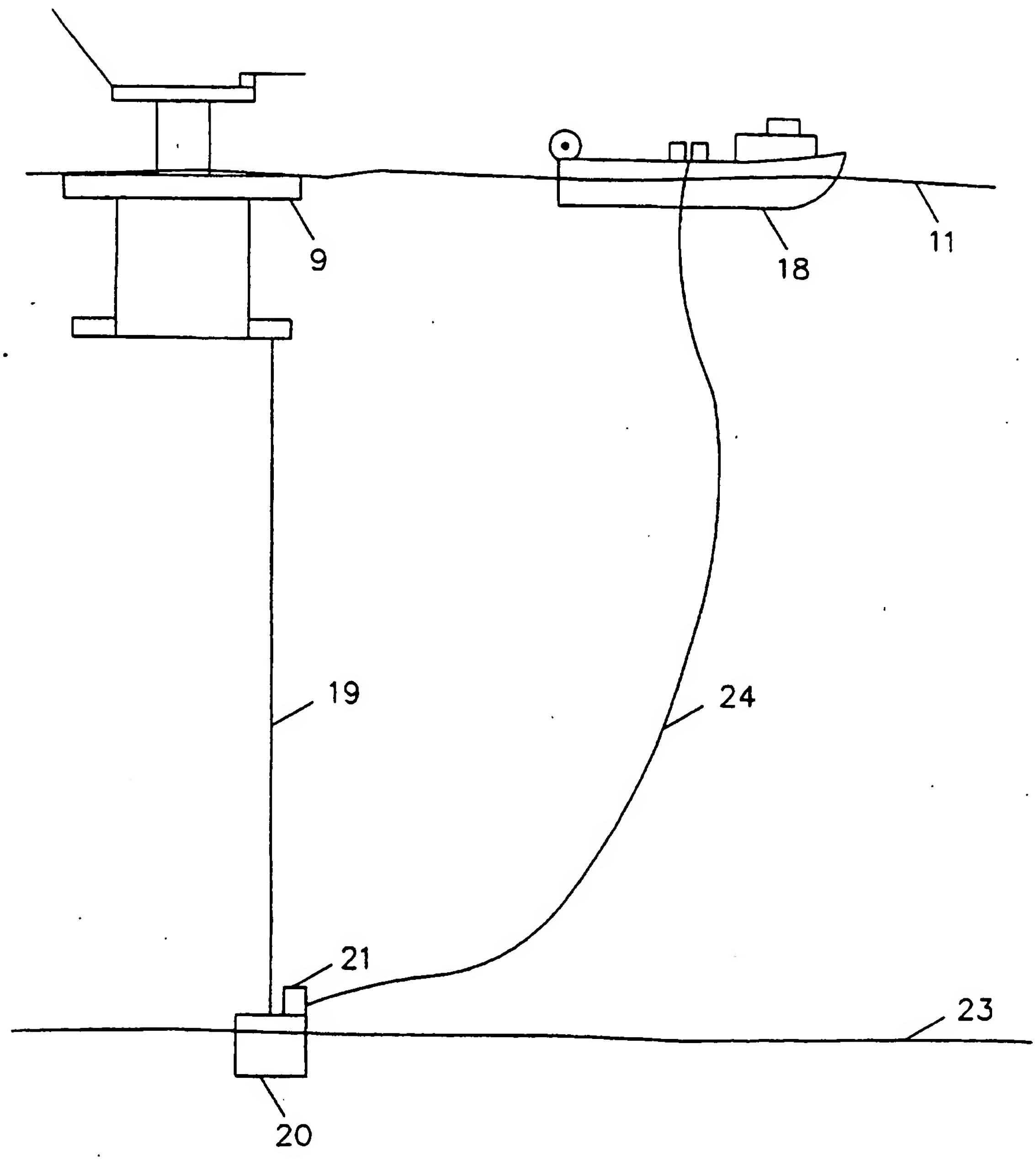


FIG. 5c

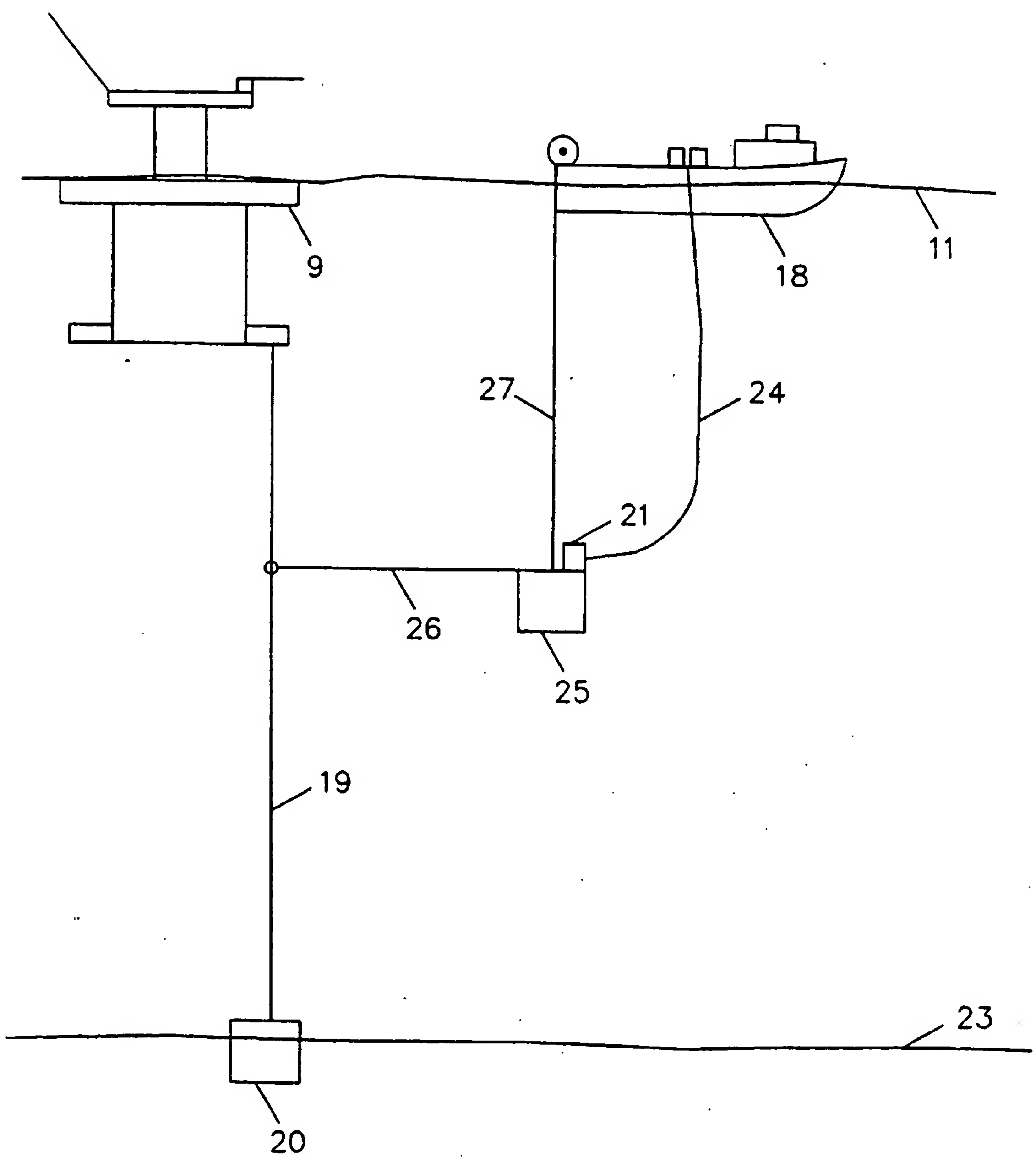


FIG. 6

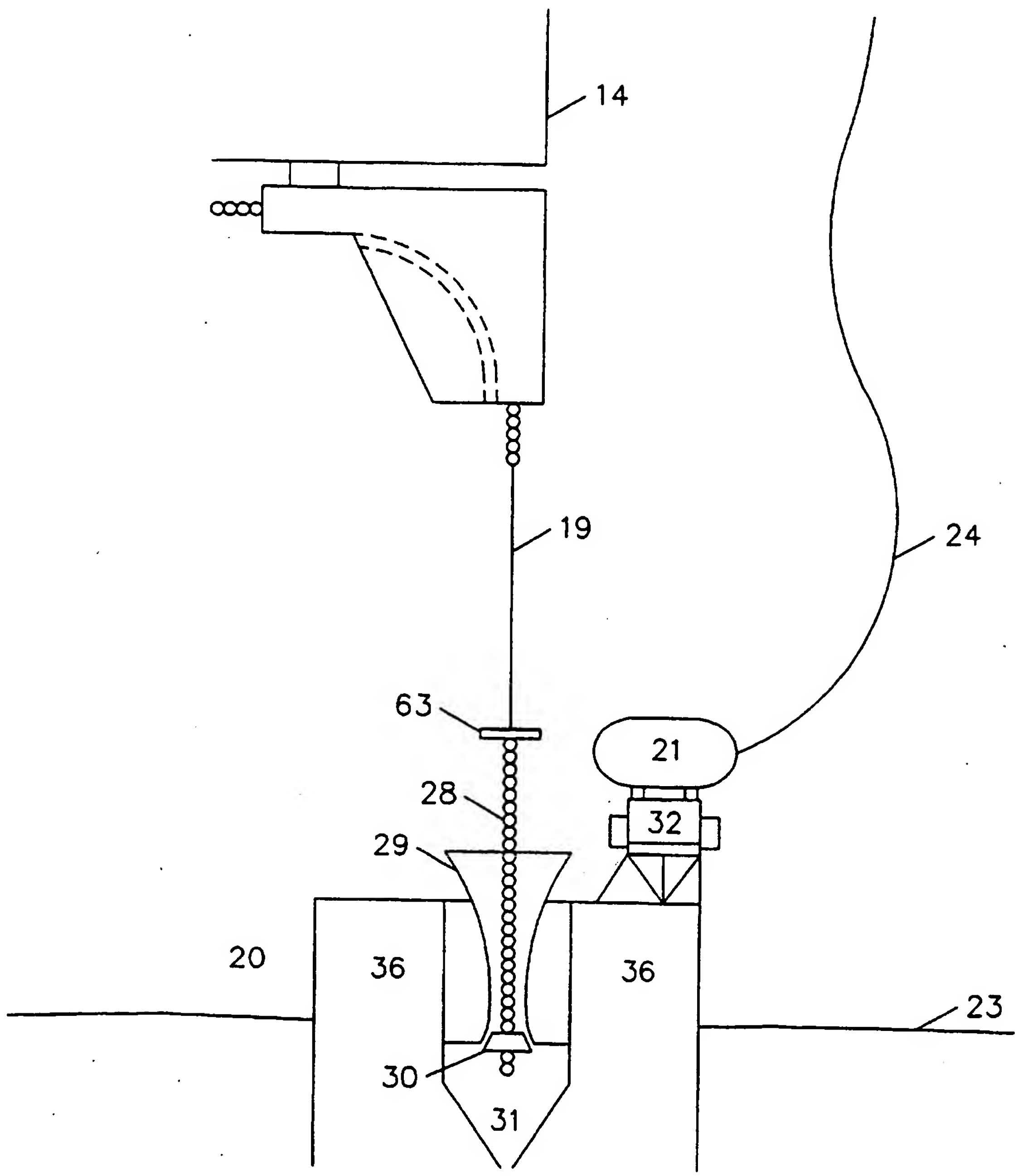


FIG. 7

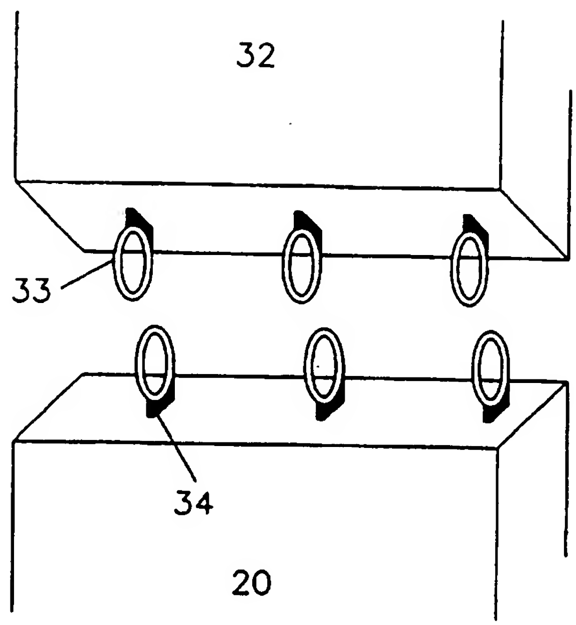


FIG. 8a

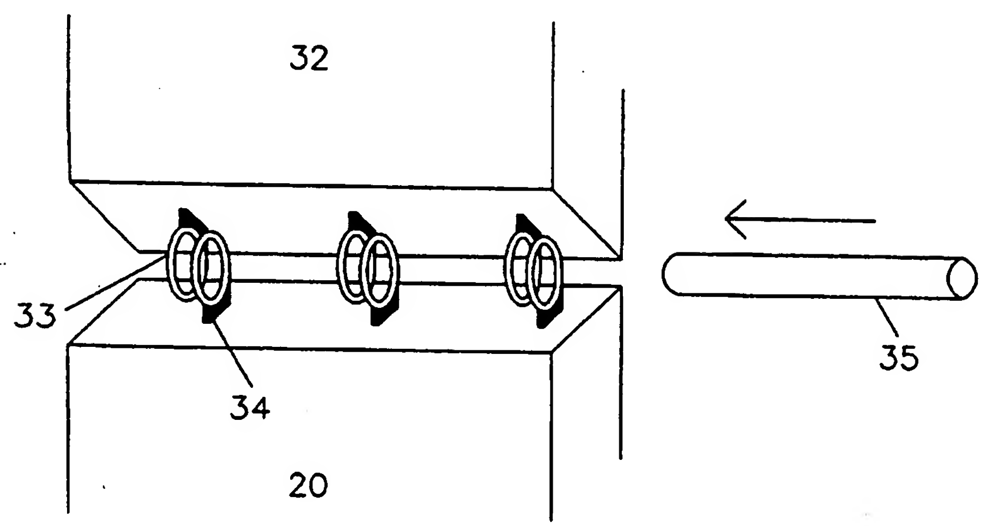


FIG. 8b

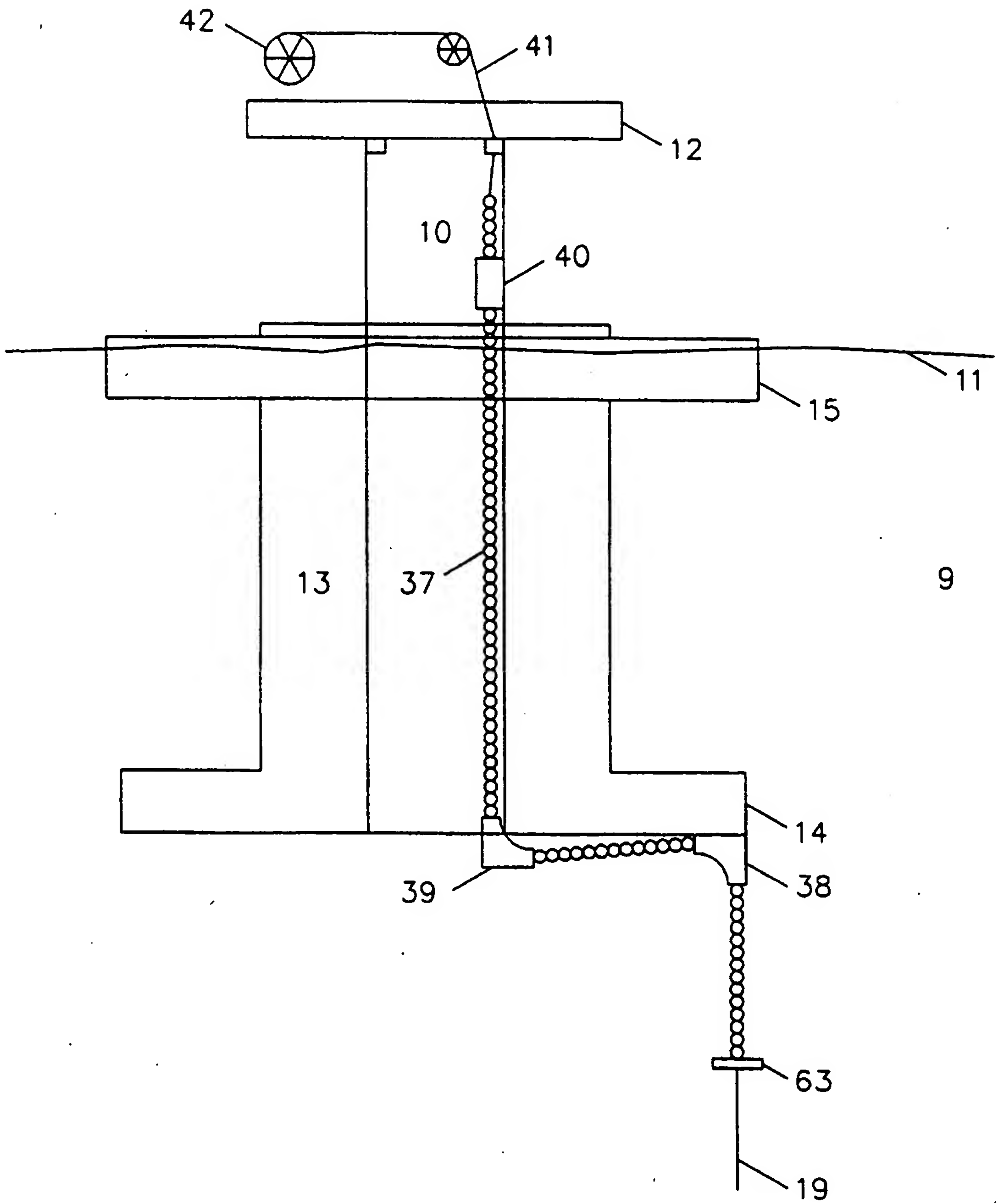


FIG. 9a

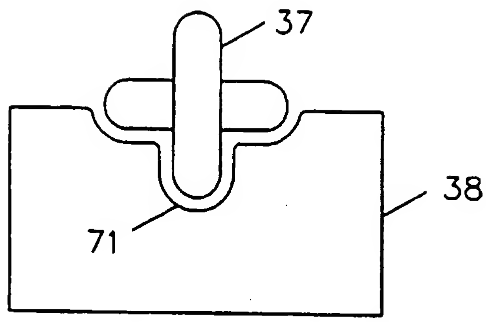


FIG. 9b

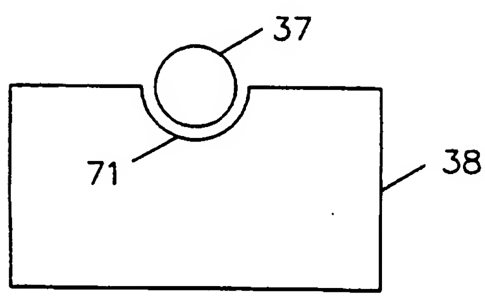


FIG. 9c

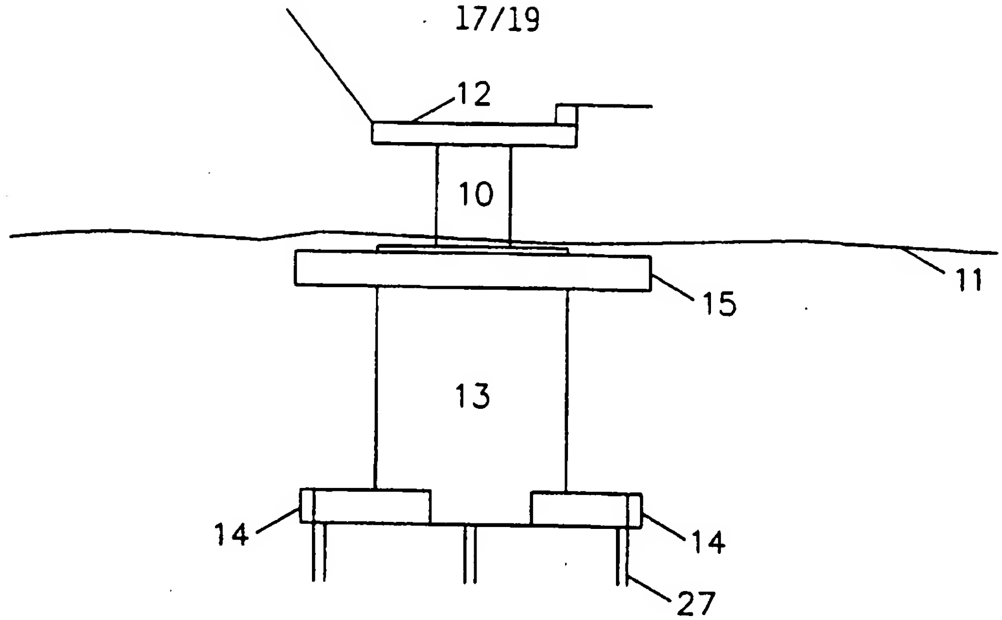


FIG. 10a

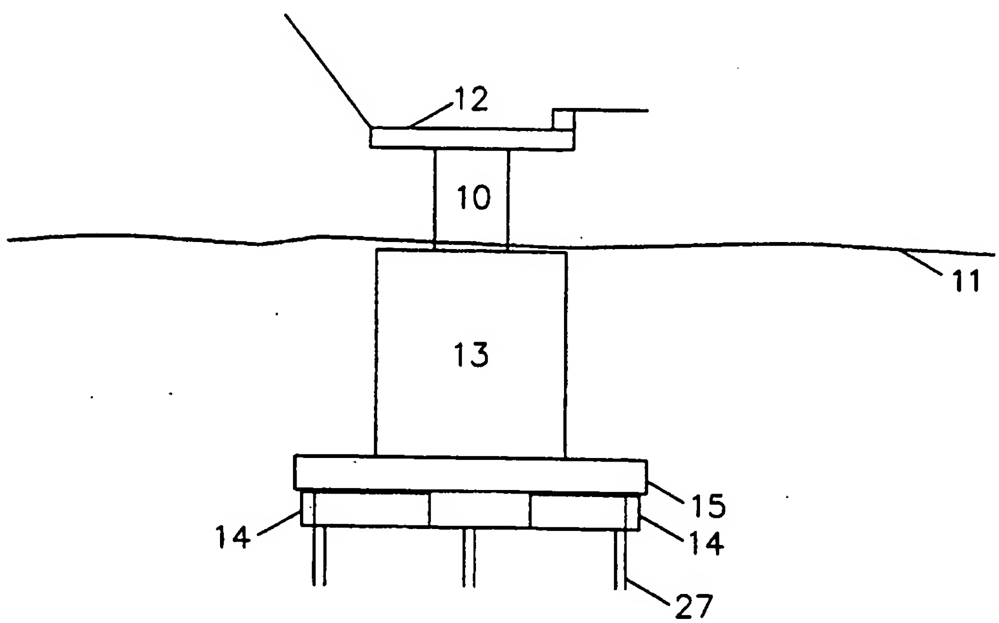


FIG. 10b

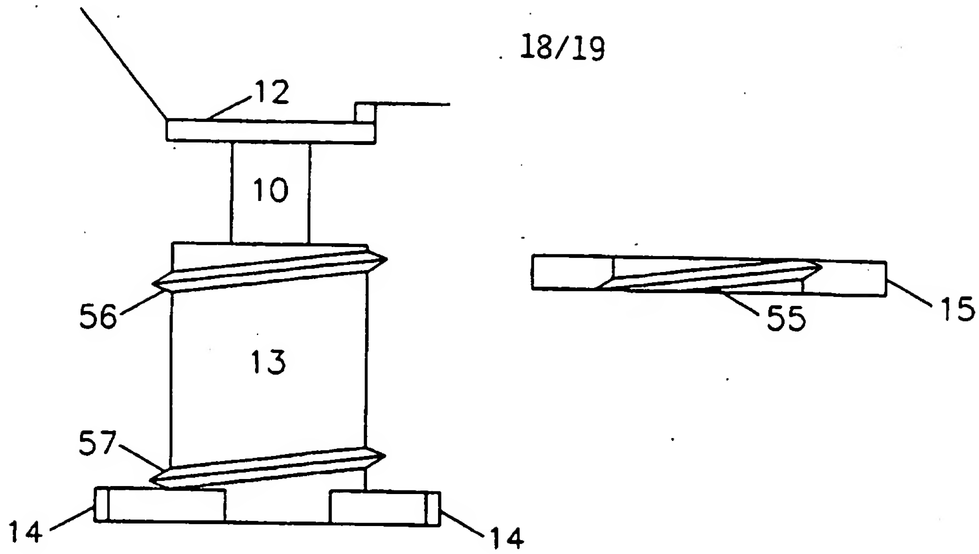


FIG. 11a

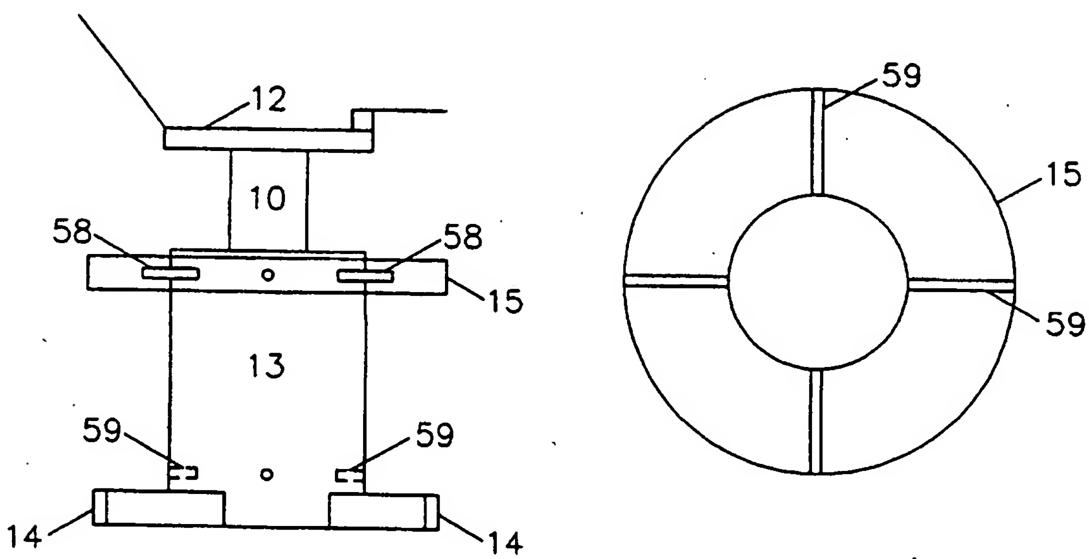


FIG. 11b

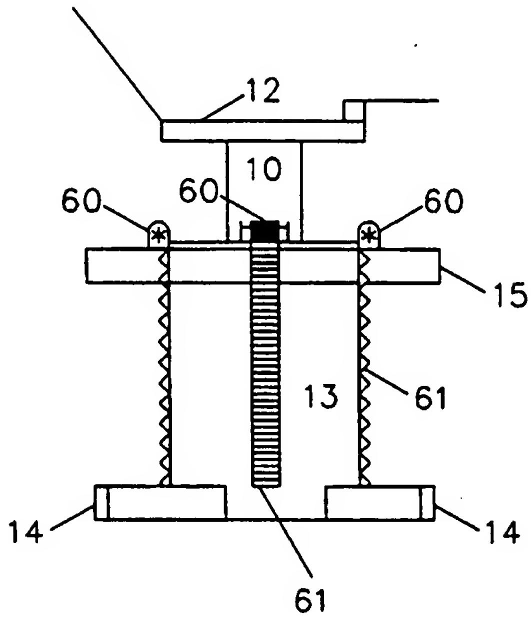


FIG. 11c

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 97/00044

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC6: B63B 35/44
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 4936710 A (PETTY ET AL.), 26 June 1990 (26.06.90), column 3, line 37 - line 51, figure 1, abstract | 1,2,4,7,8,9, 12,16,18,19 |
| A | | 5,10,11,12, 14,15,17 |
| | -- | |
| X | US 4155673 A (YASHIMA), 22 May 1979 (22.05.79), column 3, line 3 - line 23; column 4, line 22 - line 40; column 5, line 28 - line 39, figures 3,4, abstract | 1,2,4,7,8,9, 12,16,18,19 |
| A | | 10,11,14,17 |
| Y | abstract | 5,6,14,15 |
| | -- | |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"B" erlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 23 May 1997 | 02.06.97 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Christer Jönsson<br>Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 97/00044

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | DE 2450173 A1 (SANTA FE INTERNATIONAL CORP.), 18 March 1976 (18.03.76), page 9, line 19 - page 10, line 16, figure 1 | 1,2,4,7,8,9, 12,16,18,19 |
| A | | 5,10,11,14, 15,17 |
| | -- | |
| Y | GB 2097739 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ BV), 10 November 1982 (10.11.82), page 1, line 6 - line 17, figures 1-4, claims 1,5, abstract | 5,6,14 |
| | -- | |
| Y | NO 174378 B (EDWARD E. HORTON), 17 January 1994 (17.01.94), page 5, line 31 - page 6, line 6, figure 1 | 15 |
| A | | 12-17 |
| | -- | |
| | -------- | |

# INTERNATIONAL SEARCH REPORT
Information on patent family members

02/04/97

International application No.
PCT/NO 97/00044

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 4936710 A | 26/06/90 | DE 69004333 D<br>EP 0399335 A,B | 00/00/00<br>28/11/90 |
| US 4155673 A | 22/05/79 | NONE | |
| DE 2450173 A1 | 18/03/76 | CA 1044534 A<br>GB 1485164 A<br>NL 7414052 A<br>US 3967572 A | 19/12/78<br>08/09/77<br>17/02/76<br>06/07/76 |
| GB 2097739 A | 10/11/82 | AU 549934 B<br>AU 8220082 A<br>CA 1190096 A<br>FR 2503084 A,B<br>JP 57178987 A<br>NL 8101640 A<br>US 4432671 A | 20/02/86<br>07/10/82<br>09/07/85<br>08/10/82<br>04/11/82<br>01/11/82<br>21/02/84 |
| NO 174378 B | 17/01/94 | BR 8606881 A<br>AU 6338186 A<br>GB 2188966 A,B<br>US 4702321 A<br>WO 8701748 A | 03/11/87<br>07/04/87<br>14/10/87<br>27/10/87<br>26/03/87 |